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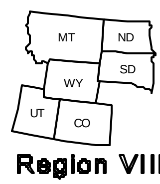
CHARACTERIZATION OF DIOXINS, FURANS AND PCBs IN SOIL SAMPLES COLLECTED FROM HISTORIC USE AREAS OF THE ROCKY MOUNTAIN ARSENAL

October 2000



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and
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APPROVALS

This report has been prepared for and by the U.S. Environmental Protection Agency, Region 8. The results and conclusions presented in this report are accepted by EPA Region 8 as correct and appropriate.

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1.0 INTRODUCTION

Dioxins are a class of chemicals that are of potential human health concern because they may pose an increased risk of cancer and other adverse health effects at very low exposure levels. As a consequence, regulatory agencies often perform a thorough evaluation of potential risks from dioxins at sites of regulatory concern, especially sites involved in the manufacture of certain chlorinated pesticides and other chemicals.

One site that is of potential concern to the USEPA and the State of Colorado is the Rocky Mountain Arsenal (RMA), located near Denver, Colorado. This site was used in the past for the manufacture of chlorinated pesticides as well as other chemicals. As a consequence, questions have been raised as to whether or not dioxin levels in site soils might be of potential concern to on-site workers or visitors.

In order to investigate this question, USEPA Region 8, working in cooperation with the State of Colorado and the Rocky Mountain Arsenal Remedial Venture Office, has undertaken a series of studies to characterize the levels of dioxins in on-site and off-site soils. This report summarizes the results of a study designed to characterize dioxin levels in the South Plants area of RMA (this was the core area historically used for pesticide manufacture), as well as at a number of other on-site locations where past land uses might have led to increased levels of dioxins.

Other reports which are part of this project and which provide additional information on the absolute and relative level of dioxins in on-site and off-site soils include:

Evaluation of Potential Human Health Risk from Dioxins, Furans and PCBs in Soil at the Western Tier Parcel of the Rocky Mountain Arsenal (USEPA 2000a)

Characterization of Dioxins, Furans and PCBs In Random Soil Samples Collected from the Rocky Mountain Arsenal (USEPA 2000b)

Characterization of Dioxins, Furans and PCBs In Soil Samples Collected from the Denver Front Range Area (USEPA 2000c)

2.0 METHODS

A detailed description of the rationale, methods, and Standard Operating Procedures (SOPs) used in this study are provided in the Project Plan for the study (USEPA 1999c). A summary of key elements of the study design and of the methods employed is presented below.

2.1 Calculation of TEQ

2,3,7,8-Tetrachlorodibenzodioxin (TCDD) is the most potent of a group of related chemicals that include other congeners of dioxins, furans, and polychlorinated biphenyls (PCBs). For the purposes of this report, the term "dioxins" is meant to refer to the set of 17 dioxins and furans and the set of 12 PCBs that bind to the aryl hydrocarbon (Ah) receptor and possess toxic characteristics similar to those of TCDD. These so-called "Ah-agonists" are listed in **Table 1**.

Not all dioxin congeners are equally toxic. The relative toxicity of a congener, compared to that of TCDD, is expressed in terms of the Toxicity Equivalency Factor (TEF). **Table 1** lists consensus TEF values for mammals (including humans), birds, and fish. These TEF values were developed by a panel of experts assembled by the World Health Organization (Van den Berg et al. 1998). Note that TEFs are often based on limited data, and so they are only approximations of the relative toxicity of each congener, rounded to the nearest half order of magnitude.

The aggregate toxicity of a mixture of different dioxins in an exposure medium (soil, food web items, etc.) is a complex function of a) concentrations of each congener in media, b) daily intake of the medium, c) absorption of each congener from that medium, and d) congener-specific TEF values. However, for purposes of screening-level evaluations of dioxin concentrations in soil samples, it is usually most convenient to calculate the concentration of TCDD-Equivalents (TEQ) present in the soil, as follows:

$$TEQ = \underset{i=1}{\overset{i=29}{\mathrm{Sum}}} \; (C_i \cdot TEF_i)$$

This approach allows a comparison of different soils in terms of a single value (the TEQ for the sample) rather than having to compare up to 29 different values. For the purposes of this report, the TEQ values are based on the TEFs for mammals (humans).

2.2 Soil Sampling

Sampling Locations

Figure 1 provides a map of the RMA, and indicates the locations of samples collected for this study.

The area of chief potential concern is the South Plants area, located in the south-center of the site. In the past, this area was the chief location of pesticide and chemical manufacturing activities. In order to plan the collection off samples in this area, a 12-section grid was laid out over the South Plants area as shown by the **blue lines** in Figure 1. Within each grid, a set of five grab samples were collected from random sampling locations, as shown by the **blue crosses**. These five grab samples were combined into a single composite sample (one for each grid), as described blow.

In addition to South Plants, there are a number of other areas on the RMA where historic land uses or waste disposal activities might have resulted in increased levels of dioxins in soil. These areas of potential concern are described in **Table 2**. One composite sample (prepared from five randomly located grab samples, as described above) were collected from each of these 10 "purposeful" sampling locations, as shown by the **black crosses** in Figure 1.

Sampling Depth

Because dioxins nearly always bind tightly to soil, it is expected that any dioxin contamination in soil that has occurred chiefly as result of atmospheric deposition and/or application of herbicides will be restricted to the surface. Thus, surface soil is the exposure medium of chief concern for both human and ecological receptors. Therefore, all soil samples for this study were collected at 0-2 inches in depth.

Sample Collection and Storage

Samples were collected using a stainless steel trowel. A ruler was used to ensure that the actual depth to which soil was collected was within ½ inch of the target (i.e., a bottom depth of no less than 1.5 inches and no greater than 2.5 inches). The soil was placed directly into a clean 16-oz amber glass jar with a teflon-lined lid, and these bottles were stored at room temperature in the dark.

2.3 Sample Preparation

All samples collected in the field were submitted under chain-of-custody to Columbia Analytical Services (CAS) for sample preparation. The first step in sample preparation was compositing of the individual sub-samples. This was achieved by removing equal portions (generally 20 g) of each of the five grab samples and placing these into a stainless steel mixing bowl. The combined samples were thoroughly mixed and placed into a new amber sample bottle. The remainder of each sub-sample was retained and stored in case there was a need to analyze any of the individual sub-samples separately.

Following compositing, each sample was air dried to constant weight, followed by coarse-sieving through a #10 (2 mm) stainless steel screen. The fraction passing the screen is referred to as the "bulk" fraction. Approximately 100 g of the bulk sample was placed in a clean amber glass jar and stored for future used. The remainder of the bulk sample was further sieved through a 60-mesh (250 um) sieve in order to isolate soil particles less than 250 um in diameter. This fraction (referred to as the "fine" fraction) was isolated because it is believed that fine soil particles are more likely to be ingested by hand to mouth contact that coarse particles, and hence it is concluded that this soil fraction is the most relevant for evaluating human health risk. All of the fine material passing the 250 um sieve was placed in a clean amber glass bottle for analysis and storage.

2.4 Sample Analysis

Following sample preparation as described above, samples were submitted under chain of custody to Midwest Research Institute (MRI) for chemical analysis. Analysis of dioxins in soil samples requires a sophisticated extraction and clean-up procedure. This procedure is detailed in USEPA (1999c) Standard Operating Procedure 11. In brief, the congeners are determined using isotope dilution method via high resolution gas chromatography/mass spectrometry (HRGC/HRMS). Samples are fortified with ^{13}C-labeled PCDD/PCDF/PCB isomers and extracted with an organic solvent. Before cleanup of the extract, the analytes are exchanged into hexane and fortified with ^{37}Cl-labeled *2,3,7,8*-tetrachlorodibenzo-*p*-dioxin. Finally, the extract is sequentially partitioned against concentrated acid and base solutions.

The Method Detection Limit (MDL) for dioxins/furans by this analytical method is defined as a signal that is 2.5 times the average signal noise. An estimate of the average signal noise is available for each analyte in each samples, so the MDL varies from sample to sample and from analyte to analyte. The Method Quantitation Limit (MQL) is based on the lowest calibration standard used and is defined as a signal that is 10-times the average signal noise. Because the noise level varies from sample to sample and analyte to analyte, DLs and QLs also vary from sample to sample and from congener to congener.

2.5 Quality Assurance

A number of steps were taken to obtain data that would allow an assessment of the accuracy and reliability of the data collected. Key elements of the Quality Assurance program are summarized below.

Performance Evaluation Samples

Performance Evaluation (PE) samples are samples of soil that contain know quantities of analyte and that are submitted blind to the analytical laboratory. In this study, three different PE samples were used. These were obtained from EPA's Quality Assurance Technical Support (QATS) laboratory . Nominal values (ppt as TEQ in bulk soil, based on PCDD/PCDF congeners only) are listed below:

Description	**Nominal Value (ppt TEQ in bulk soil)**
Native western soil	< 2
Low standard	35
Medium standard	59

One aliquot of each these three QATS PE samples was submitted to the laboratory along with each set of 14 field samples. In some cases the sample was submitted un-sieved (bulk), and in other cases the samples was sieved, and only the fine fraction was analyzed.

Field Splits and Duplicates

A field duplicate is a second sample of soil collected at the same location as the first sample was collected, by alternating scoops of soil that was placed into the sample jar and into the duplicate jar. A sample split is a specimen that is generated by dividing a single field sample into two parts; in this case, a second aliquot from four total aliquots of sieved soil was submitted from the EPA archiving laboratory in Golden, CO, to the analytical laboratory. Both field duplicate and laboratory split samples were given unique and random identifying labels, so as to be blind to the laboratory analysts. Analysis of these types of samples provided data on the variability within and between related samples. One sample of each type was submitted to the laboratory with each set of about 14 field samples.

Laboratory Quality Control Samples

Laboratory QA samples are samples prepared and run by the laboratory in a non-blind fashion to monitor the performance of the analytical method. Laboratory QA samples included **Method Blanks** (analyte-free soil), **Laboratory Control Samples** (similar to PE samples, but the identity and true concentration are known to the laboratory), and **Method Duplicates** (investigative samples that are split prior to sample preparation at the analytical laboratory).

Data Validation/Verification

All data from MRI were subjected to a data verification check that was performed by RMA contractors (see SOP 12 in the Project Plan). No significant problems were detected in this verification check.

Following verification, all data values were reviewed by EPA to assign data usability flags. **Table 3** summarizes the data quality flags codes that were used, along with a description of the effect of the flag on the data usability assessment. In accord with USEPA (1992) data usability guidelines (Data Usability for Risk Assessment in Superfund), these flags are used for producing two data sets:

1) a <u>semi-quantitative</u> set of results with a value (actual or proxy as per above flags) for each congener; this result is referred to in this report as the "**Full**" TEQ value

2) a <u>quantitative</u> data set with more certain quantitative values (actual or proxy as per above flags) for only the congeners that have no disqualifying flags (D, JN, R and LT); this result is referred to in this report as the "**Quantitative**" TEQ value.

This distinction is made to help evaluate the effects of estimated values on TEQs and to evaluate profiles.

3.0 RESULTS

Detailed analytical results for each field sample are presented in **Appendix A1**, and detailed results for each QA sample run as part of this study are presented in **Appendix A2**. Graphical representations are presented in **Appendix B**. The results are summarized below.

3.1 TEQ Values

Table 4 presents the results (expressed as ppt of TEQ) for each of the 12 composites samples collected from the South Plants area and for each of the 10 purposeful samples collected from the historic use areas at RMA..

For the samples collected from the South Plants area, Full TEQ values ranged from 3 to 101 ppt, while Quantitative TEQ values ranged from 2 to 91 ppt. The average ratio of Full TEQ to Quantitative TEQ was about 1.25. This indicates that congeners that are present below the quantitation limit contribute an average of about 25% to the estimated TEQ.

The spatial pattern of the full TEQ values for TCDDs/TCDFs (i.e., not including the contribution of PCBs) for samples from South Plants is shown in **Figure 2**. As seen, the highest values (20-94 ppt) occur in the center of the South Plants area, with concentrations of 2-6 ppt in the perimeter grids. This spatial pattern is consistent with the hypothesis that low levels of dioxins were formed and released to soil during historic operations at the South Plants area, but that the contamination is largely restricted to the manufacturing area, and rapidly decreases as a function of distance from the historic source.

For the 10 purposeful samples collected from the different historic use areas of RMA, full TEQ values based on all 29 congeners ranged from 2 to 49 ppt, while Quantitative TEQ values ranged from 1 to 47 ppt. The average ratio of Full to Quantitative was about 1.21. This indicates that congeners that are present below the quantitation limit contribute an average of about 21% to the estimated full TEQ.

The spatial pattern of the full TEQ values for TCDDs/TCDFs (i.e., not including the contribution of PCBs) for the purposeful samples from the historic use areas of RMA is shown in **Figure 3**. As seen, the highest values (10-14 ppt) occur at Stations P-3, P-4, P-5 and P-6, which are associated with the following:

> Sample P-3 is located in secondary Basin D in Section 26. This sample is composed of soils impacted by the disposal of liquid wastes from the RMA production areas.
>
> Sample P-4 is located just east of the North Plants production facility. This sample is composed of soils potentially impacted by the incineration operations in North Plants.
>
> Sample P-5 is located within the North Plants production facility. This sample is composed of soils potentially impacted by GB operations within North Plants as well as the incineration operations in North Plants.
>
> Sample P-6 is located in the Toxic Storage Yard (TSY) in Section 31. This sample is composed of soils potentially impacted by spills of various materials stored in the TSY

Full TEQ concentrations at the other sampling stations range from 1-6 ppt. These results are consistent with the hypothesis that dioxins were released to some soil locations during historic operations at RMA, but that the magnitude of the contamination is low.

3.2 Contribution of PCBs

The TEQ values presented in the right hand section of Table 4 are based on the sum of TEQ values across 17 dioxin/furan congeners and 12 dioxin-like PCBs. For the 12 samples from the South Plants area, the contribution of PCDDs and PCDFs to the TEQ is approximately 80-83%, with about 17-20% contributed by PCBs. For the 10 purposeful samples from the historic use areas, the contribution of PCBs is somewhat higher (about 33-34% on average). This is due mainly to sample P-5 which contains a substantially higher level of PCBs (about 37 ppt TEQ) than most other samples, which are generally less than 5 ppt TEQ.

3.3 Contribution of Specific Congeners

The congener composition of a soil sample may provide useful information about the source of the material, and helps to reveal which specific congeners are contributing the majority of the TEQ levels. The mean contribution of each congener to full TEQ is summarized in **Table 5**. In both the South Plants area and the historic use areas, most of the TEQ (full and/or quantitative) is contributed by pentachloro- and hexachloro-dioxins and furans, with an additional contribution from 1,2,3,4,6,7,8-HpCDD and from PCB-126. TCDD itself usually contributes only about 1-3% of the total.

3.4 Quality Assurance Samples

Quality assurance samples analyzed as part of this study indicate that the data are reliable and accurate.

Method Blanks

Full TEQ values for 2 method blanks were 0.8 and 0.2 ppt (average = 0.5 ppt). This indicates that there is no significant source in dioxin or PCB contamination within the laboratory.

Splits and Duplicates

Results for duplicates and splits are as follows:

Sample	Full	Quantitative
SP-4	6.0	4.9
SP-4 Dup	5.2	4.3
SP-8	33.9	29.5
SP-8 Split	30.2	26.1
P-5	48.8	47.4
P-5 Split	48.6	46.1

As seen, there is good agreement between splits and duplicate pairs, with an average difference of less than 2 ppt.

Blind Performance Evaluation Samples

Analytical results for the soil standards (PE samples) obtained from QATS are summarized below.

Sample	Full TEQ (ppt) (PCDD/PCDF Only)			
	Bulk		Sieved	
	Nominal	Measured	Nominal	Measured
Clean Soil	< 2		--	1.9 (N=1)
Low Standard	35	26 (N=1)	--	72 (N=1)
Medium Standard	59	77 (N=1)	--	125 (N=1)

As seen, measured values for bulk PE samples are in reasonable accord with the expected (nominal) values. For PE samples that were sieved before analysis, the measured values are about twice as high as the nominal values for the bulk PE samples. This indicates that dioxins and furans tend to be more concentrated (on a mass per unit mass basis) in fine particles than in bulk soil, as would be expected for a material that adheres to the surface of particles, since the surface area to mass ratio increases as particle size decreases.

Laboratory Spikes

Analytical recovery of congeners from 2 different laboratory spikes (nominal full TEQ = 252 ppt) were 100% and 99%, respectively.

4.0 DISCUSSION

Comparison to Human-Health Based Guidelines

One of the objectives of this study was to determine whether dioxin levels in on-site soils might be of health concern to on-site workers. The concentration in soil that is identified by USEPA as the potential level of concern for workers is 5,000-20,000 ppt (EBASCO 1994). Inspection of Table 4 reveals that all of the samples collected in this study, including the most heavily impacted samples from the South Plants area and other historic use areas, are all far below the level of potential health concern to workers. This is shown graphically in **Figure 4**.

Comparison to Area-Wide Background Levels

Figure 5 compares the distribution of concentration values observed at historic use areas of RMA with values observed at sampling locations around the Denver front range area (USEPA 2000c). As seen, the concentration values at RMA historic use areas and at South Plants are somewhat higher than for open space or agricultural areas, but tend to overlap the range of values measured at commercial and industrial areas located in the Denver front range area. Multiple pair-wise comparisons using the

Mann-Whitney rank sum test indicate that neither of the on-post data sets (South Plants, purposeful) are statistically different from the off-post data sets for commercial or industrial areas in the Denver front range area, but are different from (higher than) the open space and agricultural area data sets ($p < 0.05$).

It should also be noted that the areas of RMA with the highest dioxin levels are currently undergoing soil remediation due to the presence of organo-chlorine pesticide (OCP) contamination. Once this remediation is complete, it is expected that dioxin levels on the RMA will be approximately the same as for open space areas in the Denver front range area.

5.0 SUMMARY AND CONCLUSIONS

Using perimeter areas of the RMA as a frame of reference, the concentration of dioxins (including both PCDD/PCDF and PCB congeners) is slightly elevated in samples of soil collected from areas historically used for chemical manufacturing operations (South Plants) or waste disposal. The spatial pattern of contamination does not suggest that any significant off-site releases have occurred, and even the highest on-site levels are far below a level of health concern to on-site workers. Concentration levels tend to overlap those found at other industrial and commercial areas around the Denver front range area.

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Table 1. List of Analytes and TEFs

Class	Target Analyte	TEF		
		Mammals	Birds	Fish
Dibenzo-p-dioxins (PCDDs)	2,3,7,8-TCDD	1	1	1
	1,2,3,7,8-PeCDD	1	1	1
	1,2,3,4,7,8-HxCDD	0.1	0.05	0.5
	1,2,3,6,7,8-HxCDD	0.1	0.01	0.01
	1,2,3,7,8,9-HxCDD	0.1	0.1	0.01
	1,2,3,4,6,7,8-HpCDD	0.01	< 0.001	0.001
	OCDD	0.0001	0.0001	<0.0001
Dibenzofurans (PCDFs)	2,3,7,8-TCDF	0.1	1	0.05
	1,2,3,7,8-PeCDF	0.05	0.1	0.05
	2,3,4,7,8-PeCDF	0.5	1	0.5
	1,2,3,4,7,8-HxCDF	0.1	0.1	0.1
	1,2,3,6,7,8-HxCDF	0.1	0.1	0.1
	1,2,3,7,8,9-HxCDF	0.1	0.1	0.1
	2,3,4,6,7,8-HxCDF	0.1	0.1	0.1
	1,2,3,4,6,7,8-HpCDF	0.01	0.01	0.01
	1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.01
	OCDF	0.0001	0.0001	<0.0001
PCBs	3,3',4,4'-TCB (77)	0.0001	0.1	0.0005
	3,4,4',5-TCB (81)	0.0001	0.05	0.0001
	3,3',4,4'-5-PeCB (126)	0.1	0.1	0.005
	3,3',4,4',5,5'-HxCB (169)	0.01	0.001	0.00005
	2,3,3',4,4'-PeCB (105)	0.0001	0.0001	< 0.000005
	2,3,4,4',5-PeCB (114)	0.0005	0.0001	< 0.000005
	2,3',4,4',5-PeCB (118)	0.0001	0.00001	< 0.000005
	2',3,4,4',5-PeCB (123)	0.0001	0.00001	< 0.000005
	2,3,3',4,4',5-HxB (156)	0.0005	0.0001	< 0.000005
	2,3,3',4,4',5'-HxCB (157)	0.0005	0.0001	< 0.000005
	2,3',4,4',5,5'-HxCB (167)	0.00001	0.00001	< 0.000005
	2,3,3',4,4',5,5'-HpCB (189)	0.0001	0.00001	< 0.000005

TEF = Toxicity Equivalency Factor
TEF values are consensus estimates recommended by WHO (Van den Berg et al. 1998)

Table 2. RMA Purposeful Sample Locations and Descriptions

Sample #	Location/Description
P1	Sample P1 is located just east of the southeast corner of former Basin F in the Basin F Exterior Soils. This sample will evaluate soils that have been impacted by the windblown distribution of Basin F liquids from the spray evaporation system.
P2	Sample P2 is located in the south central portion of Section 20 in the ash disposal area. This sample will evaluate soils/ash where incinerator and electrostatic precipitator ash from Mustard demilitarization operations were disposed.
P3	Sample P3 is located in secondary Basin D in Section 26. This sample will evaluate soils impacted by the disposal of liquid wastes from the RMA production areas.
P4	Sample P4 is located just east of the North Plants production facility. This sample will evaluate soils potentially impacted by the incineration operations in North Plants.
P5	Sample P5 is located within the North Plants production facility. This sample will evaluate soils potentially impacted by GB operations within North Plants as well as the incineration operations in North Plants.
P6	Sample P6 is located in the Toxic Storage Yard (TSY) in Section 31. This sample will evaluate soils potentially impacted by spills of various materials stored in the TSY.
P7	Sample P7 is located in former burn pits and burial trenches located in Section 32. This sample will evaluate soils impacted by the pits and trenches.
P8	Sample P8 is located just southwest of the trash incinerator in Section 36. This sample will evaluate soils potentially impacted by emissions from the trash incinerator.
P9	Sample P9 is located east of the Complex/Army Trenches in Section 36. This sample will evaluate soils potentially impacted by windblown dispersion of waste and emissions from disposal and burning conducted in the trenches.
P10	Sample P10 is located near the USFWS Visitor Center in Section 2. This sample will evaluate soils in areas which are frequently visited by the public.

(Provided by CDPHE, M. Kadnuck, 12/99)

Table 3. Definition, Application, and Uses of Data Flags

Validation Flags	Meaning of Flags for Dioxin Analyses in Soils and Tissues by the MRI Lab	* Usability of DataSets	
		Full data set used (*semi-quantitative*)	**Quantitative** (qualified sub-set used)
E	Estimated Maximum Potential Concentration; the relative ion abundance ratios did not meet the acceptance limits.	use value	use ½ value
D	EMPC is caused by polychlorinated **D**iphenyl ether interference.	use ½ value	don't use
B	Analyte was detected in associated Method **B**lank, sample concentration <5x MB concentration.	use value	use ½ value
C	Concentration is above upper **C**alibration Standard; result is an estimate, flagged C by lab and J added by validator.	use value	use value
I	Recovery of 13C-labeled **I**sotopic analyte outside of criteria	use value	use value
J	Estimated: e.g., isotopic standard is outside CCAL range, native analyte recovery in LCS is outside criteria, etc.	use value	use ½ value
NJ	Presumptive evidence for the presence of an analyte with an estimated value; if used for 2378-TCDF, see "U" below.	use ½ value	don't use
S	Peak is **S**aturated; result, if calculated, is flagged by the validator as an estimate - "J".	use value	use value
U	Unconfirmed: column is not specific for 2,3,7,8-TCDF; confirmation not requested. Validator now uses "NJ" flag.	use value	use ½ value
R	Rejected: result is invalid and not usable.	use ½ EDL	don't use
***use of MRI Laboratory's reported "LT" (less than) values* <MQL (10 x Signal:Noise)**			
LT *applied **first** to data, then apply flags!*	"LT" is not a true "flag", but if a LT result is a "**detect**" **above the MDL** (2.5 x Signal:Noise = lab EDL), then	use value	use ½ value
	"LT" is not a true "flag", but if a LT result is a "**non-detect**" **below the MDL** (2.5 x Signal:Noise = lab EDL), then	use ½ EDL	don't use

* Per concepts in the 1992 EPA Data Usability for Risk Assessment in Superfund guidance, the above flags are to be used for producing two data-sets: 1) a "**Full**" set of semi-quantitative results with an **actual or proxy value for each of the 29 measured congeners**; and 2) a "**Quantitative**" partial set of results with more certain identification and more accurate quantities of congeners which have **no disqualifying flags (D, JN, R or LT) or use limited proxies (E, B, J or U)**. This distinction is made to better understand and limit the artifactual impacts of the less certain estimated values on TEQs, analyzing this sensitivity by comparing TEQs from these two data-sets and evaluating congener profiles with only the analytes that are able to be quantitated.

Source: EPA R8 Soil and RMA Tissue Studies of Dioxins, 2000, ref. RMA/EAL SOP 803

Table 4. Soil TEQ Values for Historic Use Areas at RMA

Location	Sample	Dioxins/Furans Only		PCBs Only		Total	
		Full	Quantitative	Full	Quantitative	Full	Quantitative
South Plants	SP-1	4.4	2.7	1.2	1.1	5.6	3.8
	SP-2	20.4	17.3	1.7	1.6	22.1	18.9
	SP-3	29.3	26.4	3.6	3.4	32.9	29.8
	SP-4	5.5	4.3	0.6	0.5	6.0	4.9
	SP-5	1.8	1.1	0.9	0.8	2.7	1.9
	SP-6	10.5	9.2	3.6	3.4	14.1	12.6
	SP-7	93.6	84.1	7.3	6.9	100.9	91.0
	SP-8	31.2	26.9	2.7	2.5	33.9	29.5
	SP-9	3.3	2.6	0.6	0.3	3.9	2.9
	SP-10	2.9	2.2	0.4	0.4	3.3	2.6
	SP-11	2.1	1.4	0.9	0.9	3.0	2.3
	SP-12	3.0	2.3	0.6	0.6	3.7	2.9
Purposeful	P-1	3.6	2.1	1.7	1.7	5.4	3.7
	P-2	1.2	0.7	0.3	0.1	1.4	0.8
	P-3	13.5	12.3	3.2	3.1	16.8	15.3
	P-4	12.5	12.0	2.9	2.8	15.4	14.8
	P-5	11.4	10.6	37.5	36.7	48.8	47.4
	P-6	9.6	9.4	0.9	0.8	10.5	10.3
	P-7	1.6	1.2	0.3	0.2	1.9	1.3
	P-8	3.6	3.3	2.3	2.2	5.9	5.5
	P-9	5.5	4.7	1.8	1.7	7.3	6.4
	P-10	2.0	1.5	4.7	4.4	6.7	5.9

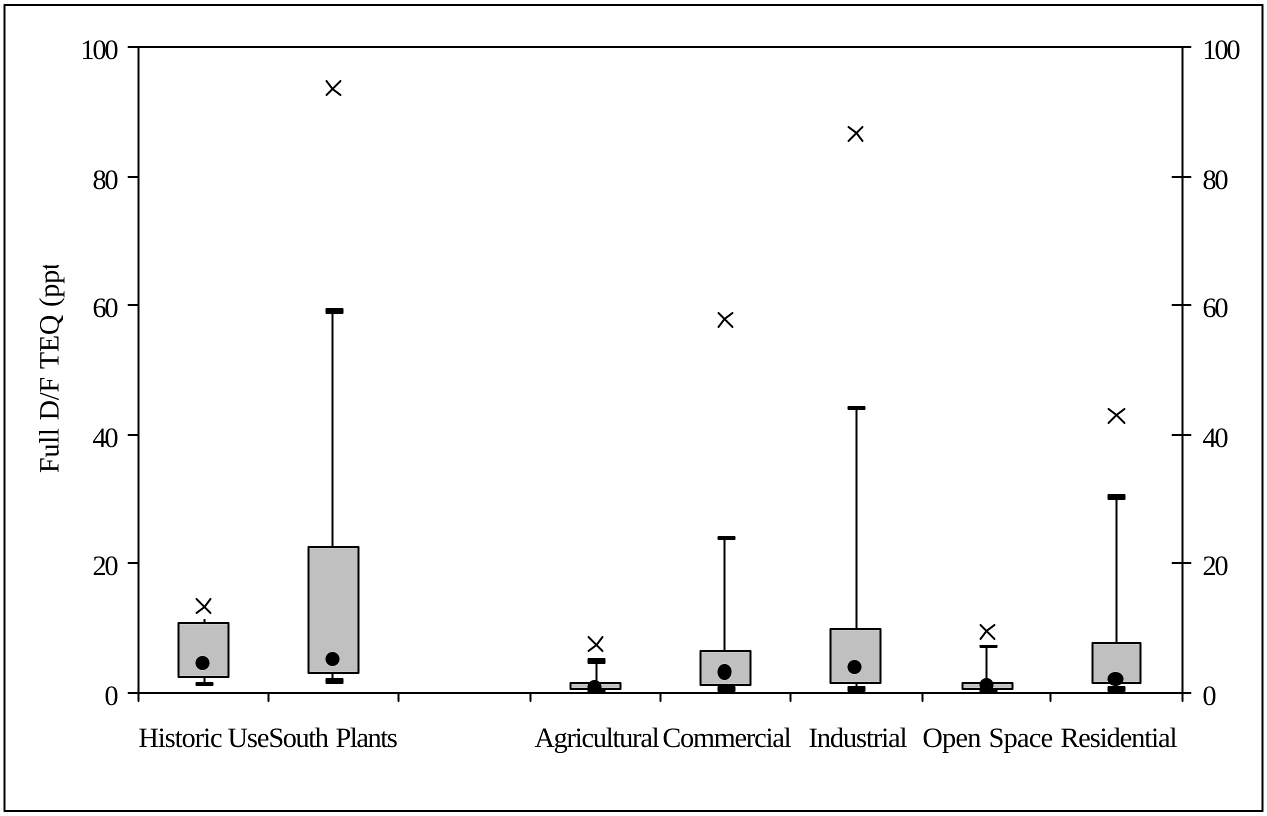
All TEQ values are expressed in units of ppt

Table 5. Average Contribution of Congeners to TEQ

Analyte	Mean Contribution to TEQ (%)			
	Purposeful Samples		South Plants Samples	
	Full	Quantitative	Full	Quantitative
2,3,7,8-TCDF	1.4%	0.0%	1.1%	0.0%
2,3,7,8-TCDD	2.5%	0.8%	3.3%	1.3%
1,2,3,7,8-PeCDF	2.1%	2.2%	5.7%	6.9%
2,3,4,7,8-PeCDF	11.0%	10.5%	12.0%	13.6%
1,2,3,7,8-PeCDD	13.0%	12.6%	7.4%	2.2%
1,2,3,4,7,8-HxCDF	7.7%	9.3%	20.6%	25.2%
1,2,3,6,7,8-HxCDF	4.7%	5.4%	11.3%	13.5%
2,3,4,6,7,8-HxCDF	3.5%	2.8%	5.4%	3.6%
1,2,3,7,8,9-HxCDF	2.1%	0.8%	5.0%	2.8%
1,2,3,4,7,8-HxCDD	1.6%	1.4%	1.1%	1.0%
1,2,3,6,7,8-HxCDD	3.3%	3.9%	1.7%	1.8%
1,2,3,7,8,9-HxCDD	2.8%	3.3%	1.4%	0.7%
1,2,3,4,6,7,8-HpCDF	3.0%	3.2%	1.3%	0.0%
1,2,3,4,7,8,9-HpCDF	0.8%	0.8%	2.3%	2.8%
1,2,3,4,6,7,8-HpCDD	7.1%	8.3%	3.4%	4.4%
OCDF	0.2%	0.2%	0.4%	0.4%
OCDD	0.5%	0.6%	0.3%	0.3%
PCB-81	0.0%	0.0%	0.0%	0.0%
PCB-77	0.2%	0.2%	0.1%	0.1%
PCB-123	0.1%	0.0%	0.0%	0.0%
PCB-118	1.7%	1.0%	1.2%	0.8%
PCB-114	0.2%	0.2%	0.2%	0.1%
PCB-105	1.1%	0.6%	0.6%	0.6%
PCB-126	26.6%	28.8%	13.1%	16.3%
PCB-167	0.0%	0.0%	0.0%	0.0%
PCB-156	2.0%	2.1%	1.0%	1.2%
PCB-157	0.5%	0.5%	0.2%	0.3%
PCB-169	0.2%	0.2%	0.2%	0.1%
PCB-189	0.0%	0.0%	0.0%	0.0%
Dioxins/Furans	67.4%	66.2%	83.4%	80.5%
PCBs	32.6%	33.8%	16.6%	19.5%
All	100.0%	100.0%	100.0%	100.0%

Cells greater than 5% have been shaded to highlight the main contributors

Figure 5. Comparison of Dioxin Levels in RMA Historic Use Areas with Denver Front Range Area Soils



Values shown are based on dioxins and furans only (PCBs are not included)